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GB 1470027
GB 1443193
GB 0882170
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(54) Connecting and sealing electric cables in an aperture in a housing

(57) A device for connecting and sealing the ends of a first set of n electrical cables 2 to the ends of a second set of n electrical cables 3 in an aperture in a housing 1 includes a hollow cylindrical open-ended outer member 7 carrying an external annular flange 16 adjacent which is a circumferential surface which, in use, engages the edge of the aperture. The outer member 7 accommodates a sealing partition member 8 comprising a hollow cylindrical portion 24 extending coaxially with the outer member 7 and carrying a first radially extending partition wall 27 having n holes formed therein and n axially extending second partition walls dividing the space within the outer member 7 into n compartments. The two ends of the outer member 7 are closed by respective resilient plugs 9 and 10 each of which has n holes formed in it. In use, the cables ends are connected by connectors 14 each of which is accommodated in a respective space defined by the walls 28 and the interior of the outer member 7 is filled with a synthetic resin material.

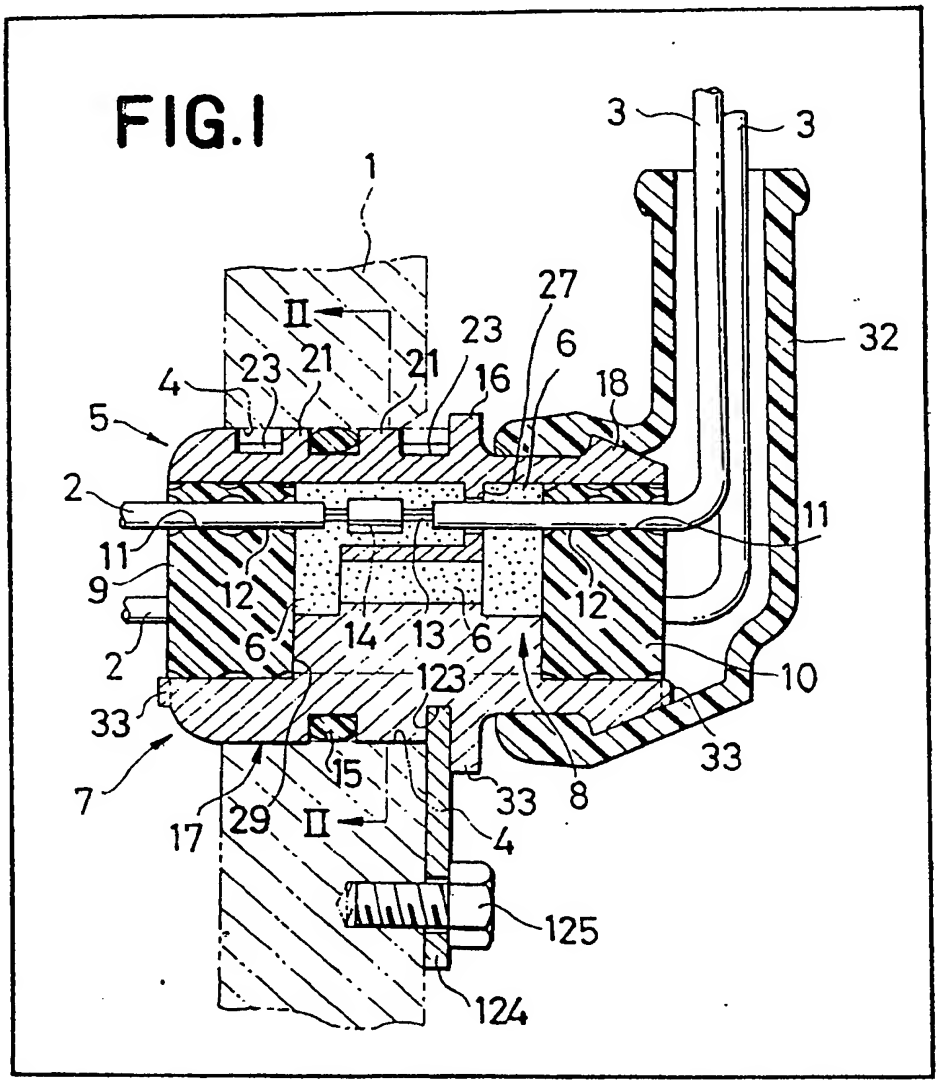

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FIG.1

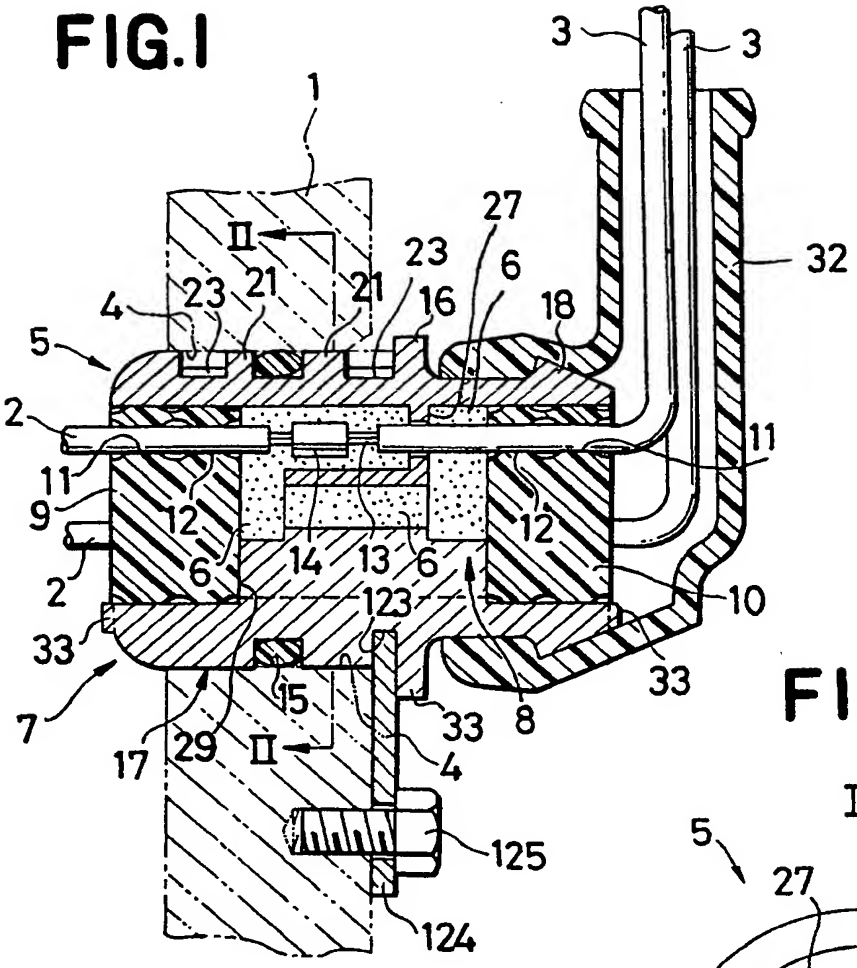

FIG.2

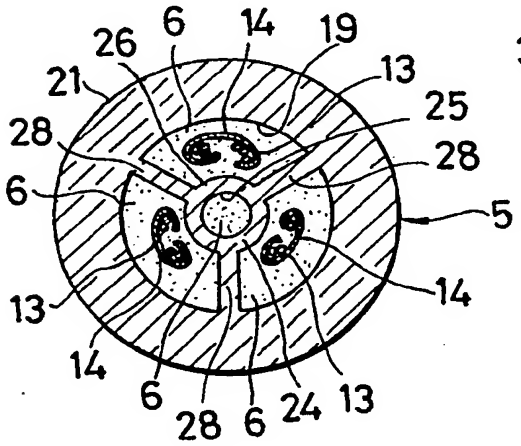

FIG.3

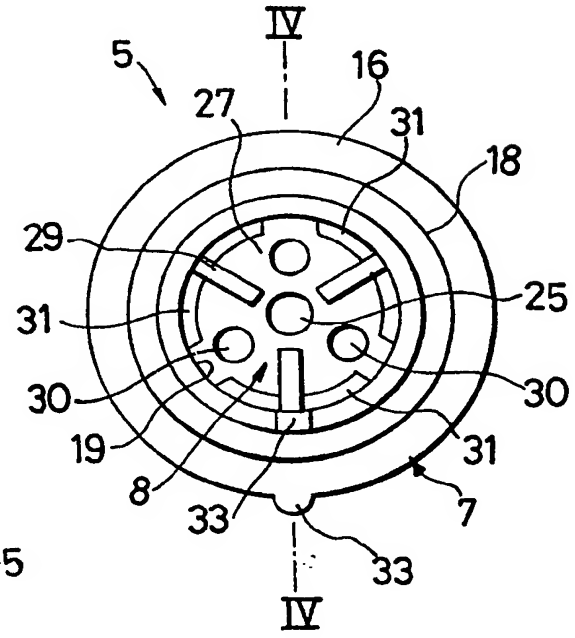

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FIG.4

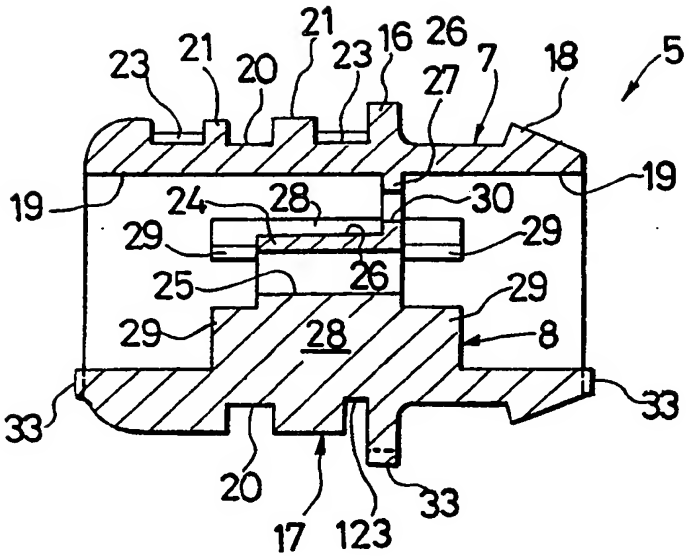

FIG.5

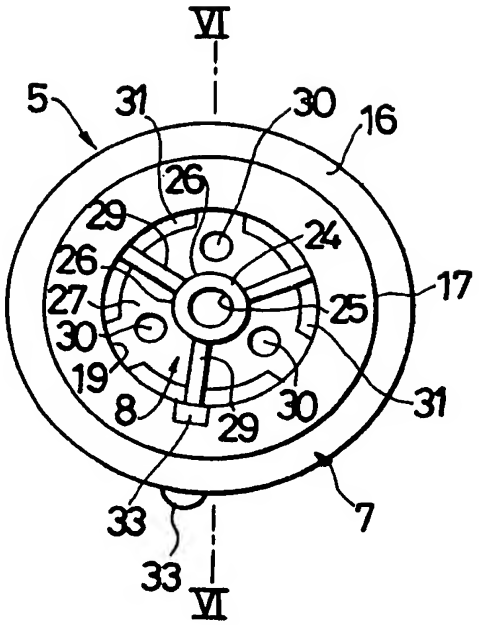

FIG.6

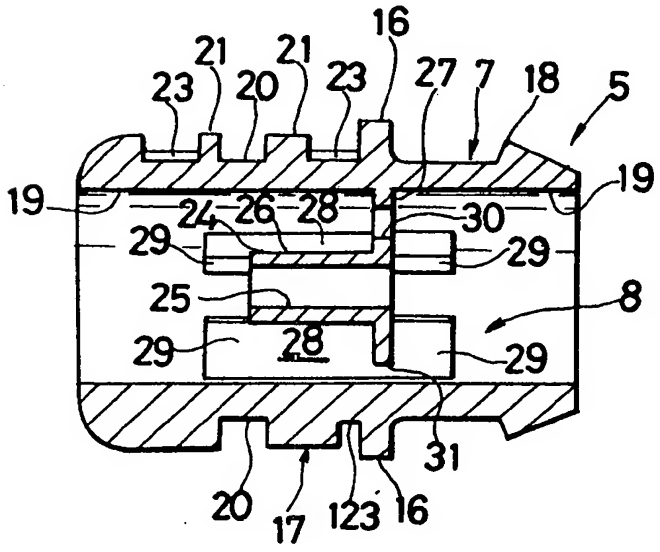

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FIG.7

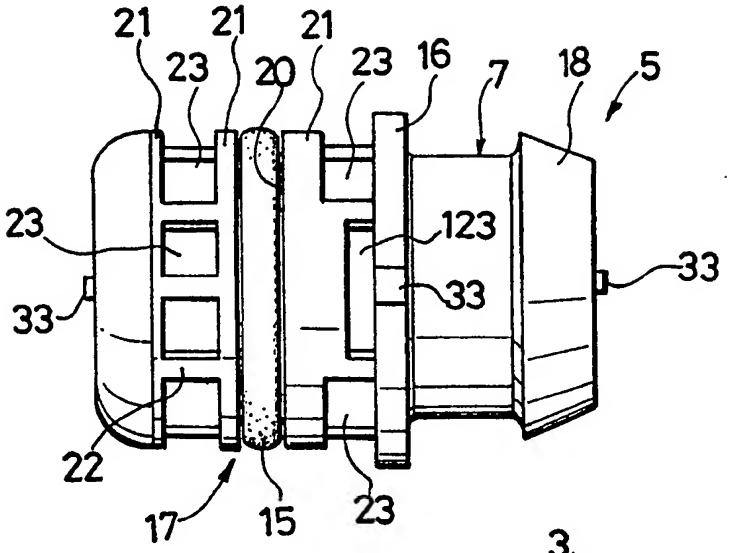

FIG.9

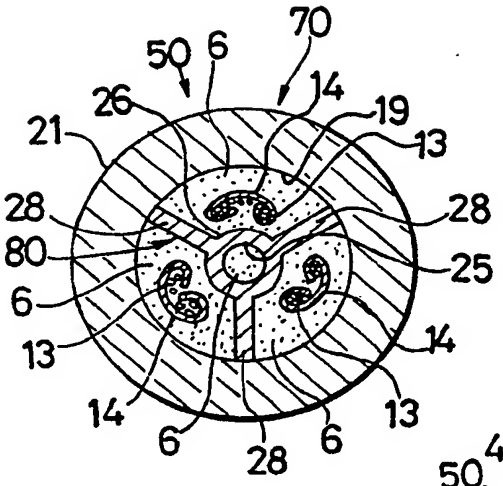

FIG.8

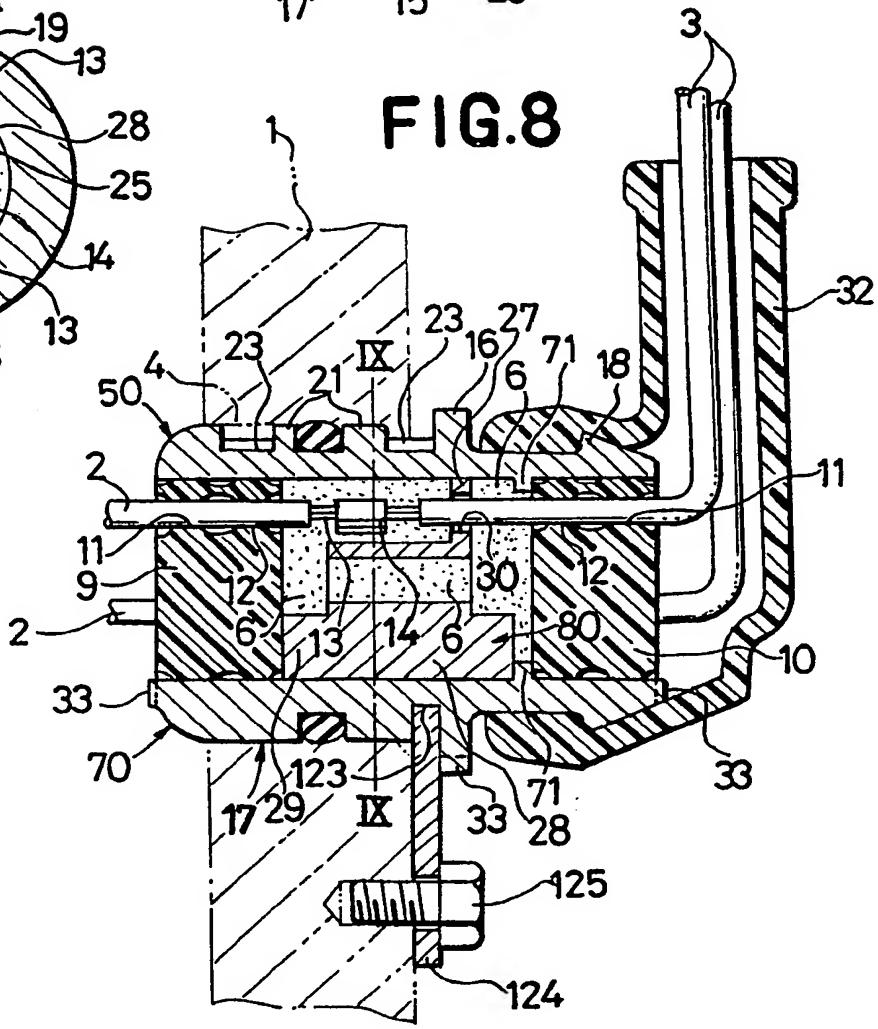

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FIG.10

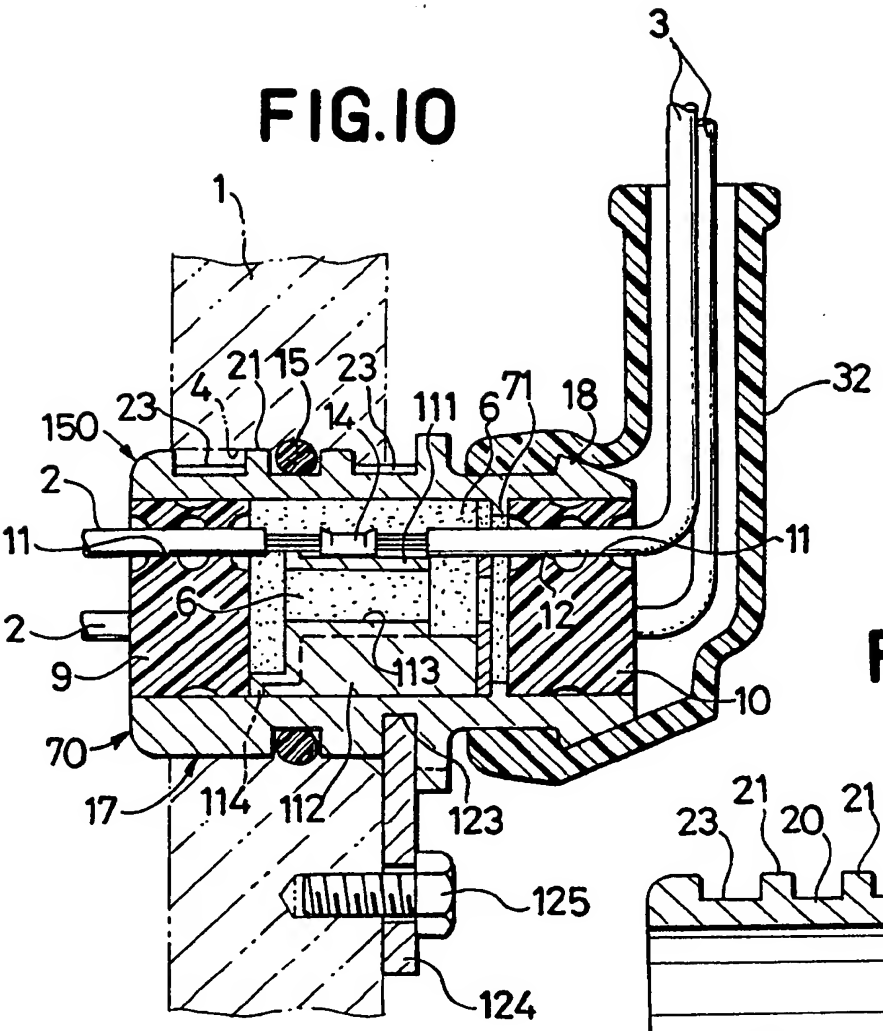


FIG.11

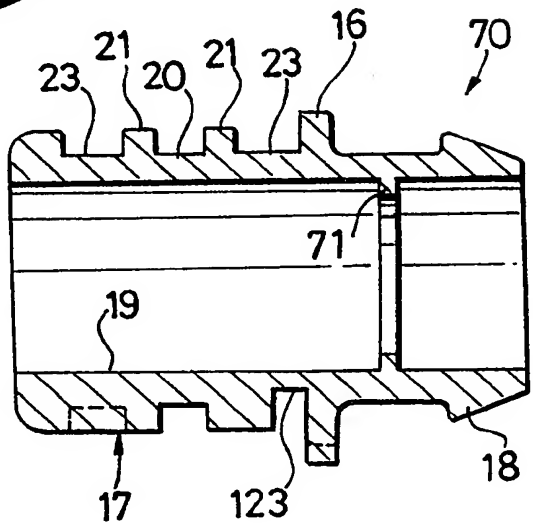
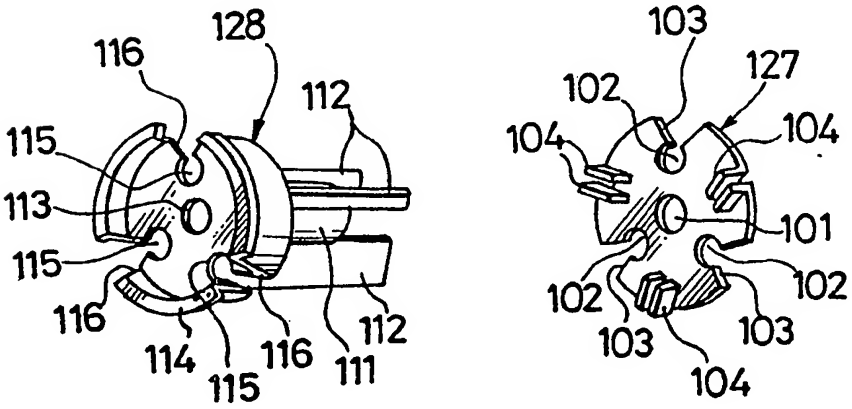


FIG.12



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SPECIFICATION

Method and device for connecting and sealing electric cables in an aperture in a housing

This invention relates to a method and a device for connecting in a liquid-tight manner electric cables in an aperture in a housing and is particularly concerned with connecting cables connected to an electrical device arranged to operate within the housing of a hydraulic machine and electric cables connected to a controller disposed outside the housing at a cable lead-out portion of the housing and with preventing the leakage of fluid contained in the housing from the inside to the outside of the housing through the cables and the intrusion of foreign substances, such as water, from the outside to the inside of the housing.

In hydraulically controlled machines in a hydraulic system, electrical devices are often operated while immersed in a hydraulic fluid. In a hydraulic control system of an automatic transmission, for instance, a solenoid valve is immersed in the hydraulic fluid and is adapted to operate under the control of an electronic controller located outside the housing of the hydraulic control system so as to control the shift valve and other components of the hydraulic control system by maintaining the pressure of the hydraulic fluid in the shift valve and other components, or by reducing the pressure by draining the hydraulic fluid.

Electric cables coated with polytetrafluoroethylene, which is referred to as Teflon (Registered Trade Mark), referred to hereinafter as Teflon cables, are commonly used for transmitting command signals to such electrical devices which operate while immersed in a hydraulic fluid, because the temperature of the hydraulic fluid often rises to a very high temperature during the operation of the hydraulic control system. This coating material has excellent heat-resisting and oil-resisting properties and Teflon cables are capable of extended service in the hydraulic fluid. However, Teflon cables are extremely expensive as compared with ordinary rubber-coated, synthetic rubber-coated or polyethylene-coated electric cables (such coated cables are referred to hereinafter simply as polyethylene cables).

Besides, since a Teflon cable or a polyethylene cable is formed by closely coating a twisted plurality of copper wires with a tubular coating layer, the Teflon cable and the polyethylene cable have a drawback that the hydraulic fluid leaks out of the housing along the interior of the cable through gaps between the cable coating and the copper wires and gaps between the component copper wires due to capillarity, even if a perfect liquid-tight seal is provided between the opening in the lead-out portion of the housing and the cable, when a single cable is connected at one end to an electrical device disposed within the housing and is connected at the other end to a controller outside the housing.

Accordingly it is an object of the present invention to provide a device and a method which prevent the leakage of a hydraulic fluid contained in a housing through the interior of an electric cable, by using separate electric cables, one connected to an electrical device disposed within the housing of a hydraulic machine while the other is connected to a controller disposed outside the hydraulic machine, and by connecting the corresponding cables and sealing gaps between the component wires of the cables with an insulating and heat-resisting synthetic resin filler by filling up the space around the junction of those cables with the synthetic resin filler within a sealing member which is attached in a liquid-tight manner to the opening in the lead-out portion of the housing.

According to the present invention there is provided a device for connecting and sealing the ends of a first set of n electrical cables to the ends of a second set of n electrical cables in an aperture in a housing, where n is an integer in excess of 1, the device including a hollow, substantially cylindrical, open-ended outer member, an annular flange extending substantially radially from the outer surface of the outer member and a circumferential engagement portion on one side thereof adapted to contact the edge of the aperture in the housing, the outer member accommodating a sealing partition member comprising a hollow cylindrical portion shorter than the outer member and disposed substantially coaxially therewith, a first partition wall at one end of the cylindrical portion having n holes formed therein and extending substantially radially between the outer surface of the cylindrical portion and the inner surface of the outer member and n second partition walls extending substantially radially from the cylindrical portion and extending axially beyond the cylindrical portion at at least one end thereof and two plug members of resilient material each having n holes formed therein and being accommodated within a respective open end of the outer member.

In one embodiment the sealing partition member comprising the cylindrical portion and the first and second partition walls is an integral unit which is removable from the outer member and the first and second partition walls contact the inner surface of the outer member.

An alternative embodiment comprises three separate components, namely the outer member, a first substantially planar sealing partition member comprising a first partition wall extending substantially radially within the outer member having a central hole formed in it and n holes arranged around the central hole and communicating with the periphery of the first sealing partition member and a second sealing partition member including the hollow cylindrical portion to one end of which a bowl-shaped structure is connected and the peripheral surface of which carries the n second partition walls, the bowl-shaped structure having a substantially

radially extending portion with a central hole formed in it and n holes arranged around the central hole and communicating with the periphery of the radially extending portion and a substantially axially extending portion in which apertures are formed in positions corresponding to and communicating with the n holes in the radial portion, the peripheral region of the first sealing partition member carrying n pairs of spaced projections between which the n second partition walls are retained, the inner surface of the outer member carrying an annular protrusion engaged by the first sealing partition member.

The invention also embraces such a device in situ in an aperture in a housing connecting the ends of two sets of n electrical cables, the first set of cables passing through respective holes in one plug member and the second set of cables passing through respective holes in the other plug member and in the first partition wall, their ends being connected to those of the first set of cables by connectors which are accommodated in respective peripherally spaced spaces defined by adjacent pairs of second partition walls, at least the space between the first partition wall and the plug remote therefrom being filled with an electrically insulating synthetic resin material.

According to a further aspect of the present invention there is provided a method of connecting and sealing the ends of a first set of n electrical cables to the ends of a second set of n electrical cables in an aperture in a housing using such a device in which the ends of the first set of cables are passed through respective holes in one plug member, the ends of the second set of cables are passed through respective holes in the other plug member and in the first partition wall, the two sets of cable ends are connected, the connections situated in respective peripherally spaced spaces defined by adjacent pairs of second partition walls, the one plug member is inserted into one end of the outer member to define a gap between it and the adjacent end of the hollow cylindrical portion, an electrically insulating flowable synthetic material is introduced through the hollow cylindrical portion to fill at least the space between the one plug member and the first partition wall, the other plug member is inserted in the other end of the outer member and the device is inserted into the aperture in the housing with its circumferential engagement portion engaging the edge of the aperture in a liquid-tight manner.

Further features and details of the present invention will be apparent from the following description of certain specific embodiments which is given by way of example with reference to the accompanying drawings, in which:—

Figure 1 is an axial sectional view of a first embodiment of the present invention;

Figure 2 is a cross-sectional view on the line II—II in Figure 1;

Figure 3 is a right side elevation of the sealing member shown in Figure 1;

Figure 4 is an axial sectional view on the line IV—IV in Figure 3;

Figure 5 is a left side elevation of the sealing member shown in Figure 1;

Figure 6 is an axial sectional view on the line VI—VI in Figure 5;

Figure 7 is a front elevation of the sealing member shown in Figure 1;

Figure 8 is an axial sectional view of a second embodiment of the present invention;

Figure 9 is a cross-sectional view on the line IX—IX in Figure 8;

Figure 10 is an axial sectional view of a third embodiment of the present invention;

Figure 11 is an axial sectional view of the outer sealing member shown in Figure 10; and

Figure 12 is an exploded perspective view of the sealing partition members of the embodiment of Figures 10 and 11.

Referring to Figure 1, three electric cables 2 to be connected to an electrical device, not shown, which operates in a housing 1 and three electric cables 3 to be connected to a controller, not shown, disposed outside of the housing 1 are electrically connected within a sealing member 5 secured within a hole 4 formed in a lead-out portion of the housing 1 and the space around the junction of the cables is filled with a synthetic resin filler 6.

The sealing member 5 consists of a sealing outer cylinder 7 and a sealing partition member 8, which will be described in detail below. Cylindrical plug members 9 and 10 made of an elastic material, such as soft rubber or a synthetic rubber, are fitted in the opposite opening ends of the sealing outer cylinder 7 axially of the sealing outer cylinder 7 and resiliently fixed thereto. Three through holes 11 extending in the axial direction are formed in each of the plug members 9 and 10 substantially at the same circumferential intervals for receiving the electric cables 2 and 3 therein. Annular protrusions 12 are formed on the inside surface of each of the through holes 11 of the plug members 9 and 10 in order to provide an increased surface pressure for the interfaces between the plug members 9 and 10 and the electric cables 2 and 3 for attaining liquid-tight sealing. Similar annular protrusions are formed concentrically and axially at the corresponding positions with respect to the annular protrusions 12 on the cylindrical outer circumference of the plug members 9 and 10 in order to provide an increased surface pressure for the interface between the plug members 9 and 10 and the sealing outer cylinder 5 for attaining liquid-tight sealing.

The coatings of the corresponding ends of the electric cables 2 and 3 are stripped off to expose the component copper wires 13 and each pair of the corresponding ends 13 of the electric cables 2 and 3 are inserted into a C-shaped joint terminal 14 formed of a metal plate and the electric cables 2 and 3 are electrically joined by crimping the joint terminal 14 (Figure 2). An O-ring 15 is provided on the outer circumference of the sealing outer cylinder 7 for the liquid-tight

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engagement between the outer cylinder 7 and the hole 4 of the housing 1.

The sealing member 5 is formed of a synthetic resin, such as nylon 66, having oil-resistance, heat resistance, moderate elasticity and excellent strength. An exemplary construction of the sealing member 5 is illustrated in detail in Figures 3 to 7. Figure 3 is a right side elevation of the sealing member 5. Figure 4 is a sectional view taken along a line IV—IV of Figure 3, Figure 5 is a left side elevation of the sealing member 5. Figure 6 is a sectional view taken along a line VI—VI of Figure 5. Figure 7 is a front elevation of the sealing member 5. The sealing outer cylinder 7 is formed as a hollow cylinder having open opposite ends, and having a radially extending flange 16 formed on the outer circumference thereof, a circumferential fitting portion 17 formed on one side of the flange 16 for fitting engagement with the hole 4 formed in the lead-out portion of the housing 1, an annular protrusion 18 of triangular section formed on the other side of the flange 16 and a cavity defined by a cylindrical inside surface 19. The central portion of the circumferential fitting portion 17 is annularly recessed over its circumference to form an annular groove 20 for receiving an O-ring 15 between circumferential annular ribs 21 formed on both sides of the annular groove 20. Ribs 22 are formed perpendicularly to the annular ribs 21. Recesses 23 are defined by the ribs 21 and 22. When the outer cylinder 7 of the sealing member is fitted in the hole 4 with the circumferential fitting portion 17 in fitting engagement with the hole 4, the elasticity of the ribs 21 and 22 serves to firmly retain the outer cylinder 7 in the hole 4. A straight groove 123 is formed in the circumferential fitting portion 17 at a position adjacent to the flange 16. A key plate 124 is fixed to the housing 1 with a bolt 125 with one side end portion thereof received in the groove 123 for preventing rotation and axial movement of the sealing member 5.

The sealing partition member 8 consists of a hollow short cylinder 24 of a length shorter than that of the outer cylinder 7 having a centre bore 25 of small diameter open at the opposite ends and disposed in the outer cylinder 7 concentrically with the inside surface 19 thereof, an annular first partition wall 27 formed at one end of the short cylinder 24 in a plane substantially perpendicular to the centre axis of the short cylinder 24 extending between the outer circumference 26 of the short cylinder 24 and the inside surface 19 of the outer cylinder 7 and three plate-shaped radial second partition walls 28 formed in planes including the centre axis of the short cylinder 24 and substantially equi-angularly spaced around the centre axis of the short cylinder 24 and extending between the outer circumference 26 of the short cylinder 24 and the inside surface 19 of the outer cylinder 7. The second partition walls 28 extend a short distance axially of the short cylinder 24 at both ends to form stopper portion 29. The first partition wall 27 has axial through holes 30 formed in sections defined by every two adjacent second partition walls 28 and small openings 31 formed on the circumference thereof on both sides of each stopper portion 29 of the second partition wall 28.

In the exemplary sealing member 5 shown in Figures 3 to 6, the sealing outer cylinder 7 and the sealing partition member 8 are shown as formed in an integral unit with the repective outer edges of the first partition wall 27 and the second partition walls 28 joined to the inside surface 19 of the outer cylinder 7.

Reference numeral 32 indicates a protective rubber cover engaging the protrusion 18 of the sealing outer cylinder 7 and covering the electric cables 3, which defines the direction of leading-out of the electric cables.

A method for connecting the electric cables 2, 3 by using the above-mentioned sealing member 5 will now be described.

The free end of each of the three electric cables 2, which are electrically connected at one end to an electric device which operates within the housing of a hydraulic machine, is led out through the hole 4 formed in the lead-out portion of the housing 1, is passed through the through hole 11 of the plug member 9, respectively, and is stripped off to expose the copper wires 13.

The free end of each of the three electric cables 3, which are electrically connected at one end to a controller disposed outside of the housing 1, is passed through the rubber cover 32 and the through hole 11 of the plug member 10, respectively, then inserted into the outer cylinder 7 of the sealing member 5 through one open end thereof and is passed further through the through hole 30 of the first partition wall 27, respectively, and through the corresponding one of the three spaces defined by the second partition walls 28, the outer circumference 26 of the short cylinder 24 and the inside surface 19 of the outer cylinder 7, respectively, and finally is led out from the other opening end of the outer cylinder 7. The end portion of the electric cables 3 is stripped off to expose the copper wires 13.

The respective copper wires 13 of the corresponding electric cables 2 and 3 are inserted into the C-shaped joint terminals 14 formed of a metal plate and are interconnected by crimping the joint terminal 14.

The electric cables 3 connected to the controller are pulled to draw the joint terminals 14 joining the electric cables 2 and 3 into the outer cylinder 7. When the joint terminals 14 are drawn into the outer cylinder 7, the joint terminals 14 stay in the space defined by the second partition walls 28, the short cylinder 24 and the outer cylinder 7, because the sectional size of the joint terminals 14 is designed so that the joint terminals 14 cannot pass through the through holes 30 of the first partition wall 27.

The plug member 9 holding the electric cables 2 connected to the electrical device which operates within the housing 1 is fitted in the opening of the outer cylinder 7 of the sealing member 5 until one end surface of the plug

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member 9 is brought into abutment with the stopper portions 29 of the second partition walls 28. It is preferable to adjust the position of the joint terminals 14 to an intermediate position between the first partition wall 27 and the plug member 9. The outer circumference of the plug member 9 is in elastic and liquid-tight engagement with the inside surface 19 of the outer cylinder 7. The stopper portions 29 serve to form a small space between the plug member 9 and the short cylinder 24.

A filler 6 made of an excellently insulating, heat-resisting and oil-resisting synthetic resin, such as epoxy resin or silicon resin, is poured into the axial centre bore 25 in a well fluidized state through one opening end of the short cylinder 24 located at the upper position of the sealing member 5 while the sealing member 5 is held with its axis vertical. The filler 6 which is poured into the axial centre bore 25 flows through the other opening end of the axial centre bore 25 into the space defined between the plug member 9 and the short cylinder 24, then into the three spaces defined by the second partition walls 28 and the outer circumference 26 of the short cylinder 24 of the sealing partition member 8 and the inside surface 19 of the outer cylinder 7, whereby the end portions of the electric cables 2 and 3, the copper wires 13 and the junctions formed by the joint terminals 14, which are disposed in the space between the sealing outer cylinder 7 and sealing partition member 8, are buried in the filler 6 and the space is filled up with the filler 6. The openings 31 formed in the first partition wall 27 allow air to be discharged therethrough from the space between the short cylinder 24 and the plug member 9 when the filler 6 is poured to fill up the space to prevent the formation of bubbles in the filler 6. After the space between the plug member 9 and the first partition wall 27 has been filled up with the filler 6, the surplus filler flows through the openings 31 and gaps between the through holes 30 and the electric cables 3 from the first partition wall 27 into the opening end of the outer cylinder 7. When the amount of the filler 6 applied reaches an appropriate amount, the supply of the filler 6 is interrupted and the surface of the filler 6 contained in the opening end is in a plane substantially perpendicular to the centre axis of the inside surface 19 of the outer cylinder 7. The plug 10 is then fitted in the opening end immediately or the plug 10 is fitted in after the filler 6 has been solidified. The appropriate amount of the filler 6 to be supplied into the opening end of the outer cylinder 7 is an amount which is sufficient to submerge the stopper portions 29 in the filler 6 when the surface of the filler is disposed as described hereinbefore.

After the filler 6 has solidified, the sealing member 5 is fitted in the hole 4 formed in the lead-out portion of the housing 1 with the circumferential fitting portion 17 of the outer cylinder 7 in liquid-tight contact with the hole 4 and the rubber cover 32 is attached to the outer cylinder 7.

In the drawings, reference numeral 33 designates positioning projections formed integrally on the outer cylinder 7 for use in fitting the sealing member in the hole 4 of the housing 1.

The connecting and sealing device of the present invention formed as described hereinbefore is capable of perfectly sealing the electric cable lead-out portion to prevent the leakage of the hydraulic fluid contained in the housing, since the electric cables 2 each connected at one end to the electrical device which operates within the housing 1 are passed through the through holes 11 of the plug member 9 in a liquid-tight manner into the interior of the outer cylinder 7 of the sealing member 5 and are electrically connected to the corresponding ends of electric cables 3 each connected at the other and thereof to the controller by means of the joint terminals 14 within the space defined by the inside surface 19 of the outer cylinder 7, the outer circumference 26 of the short cylinder 24 and the second partition walls 28 of the sealing partition member 8. The gaps between the coatings and the individual copper wires 13, the gaps between the copper wires 13 and the space around the joint terminals 14 are filled with the filler 6 filling up at least the space between the plug member 9 and the first partition wall 27, whereby any movement of the hydraulic fluid within the electric cables 2 due to capillarity is prevented by the filler 6 so that the hydraulic fluid will not be transmitted to the electric cables 3 extending outside of the housing. The three junctions between the electric cables 2 and the electric cables 3 are well insulated from each other and the sealing member 5 filled with the filler 6 closes the hole 4 formed in the housing 1 in a liquid-tight manner.

Figures 8 and 9 show another embodiment of the present invention, wherein the construction of the parts designated by the same reference numerals as used in Figures 1 to 7 are the same as the constructions of the corresponding parts shown in Figures 1 to 7, except that the sealing member 50 consists of an outer cylinder 70 having a small annular radial protrusion 71 extending from its inner circumference and a separate sealing partition member 80, and that the sealing partition member 80 is fitted in the outer cylinder 70 with the free edges of the first partition wall 27 and the second partition walls 28 in fitting engagement with the inside surface 19 of the outer cylinder 70 and is positioned by means of the annular protrusion 71.

A simple description of part of the method of connecting electric cables 2 and 3 by means of the sealing member 50 will now be given and the remainder will be apparent from the description which is provided with reference to Figure 1.

Three electric cables 2, each electrically connected at one end thereof to an electrical device, are passed through the through holes 11

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of the plug member 9 and are stripped off to expose the copper wires 13.

Three electric cables, 3 each electrically connected at one end thereof to a controller, are passed through the holes 11 of the plug member 10 and then introduced into one open end of the sealing outer cylinder 70 in the form of a hollow cylinder and withdrawn from the other opening of the outer cylinder 70 and then passed through the holes 30 of the first partition wall 27 of the sealing partition member 80 and the other end of each of the electric cables 3 are stripped off to expose the copper wire 13. The electric cables 2 and 3 are electrically connected by means of the joint terminals 14.

The junctions between the electric cables 2 and 3 formed by the joint terminals 14 are disposed within the corresponding spaces between the second partition walls 28 of the sealing partition member 80. The sealing outer cylinder 70 is moved along the circumference of the sealing partition member 80 until the annular protrusion 71 is brought into abutment with the stopper portions 29 of the second partition walls 28, so that the sealing outer cylinder 70 and the sealing partition member 80 are joined together with the free edges of the first partition wall 27 and the second partition walls 28 in fitting engagement with the inside surface 19 of the outer cylinder 70.

The plug member 9 is elastically fitted in the opening of the outer cylinder 70 until the plug member 9 comes into abutment with the stopper portions 29 of the second partition wall 28 and is held there elastically.

The fluidized filler 6 is poured through the one open end of the short cylinder 24 to fill up at least the space formed within the outer cylinder 70 between the plug member 9 and the first partition wall 27 of the sealing partition member 80. The filler 6 fills up the spaces around the junctions between the electric cables 2 and 3 formed with the joint terminals 14 and the space between the plug member 9 and the first partition wall 27. The filler 6 also flows into and fills up gaps remaining in the engaging parts between the outer cylinder 70 and the sealing partition member 80 so that the outer cylinder 70 and the sealing partition member 80 are firmly joined together when the filler 6 solidifies.

The method employing the sealing member 50 is the same as the method employing the sealing member 5 except that the electric cables 3 can be passed through the holes 30 of the first partition wall 27 of the sealing partition member 80 whilst outside the cylinder 70 and that the positioning of the junctions between the electric cables 2 and 3 formed with the joints 14 in the respective central portion between the second partition walls 28 can be attained easily as compared with the method employing the sealing member 5. Otherwise, the construction of the connecting and sealing device using the sealing member 50 is substantially the same as that using the sealing member 5.

Figures 10 to 12 show still another embodiment of the present invention. In this embodiment, a sealing member 150 consists of a sealing outer cylinder 70, a first sealing partition member 127 and a second sealing partition member 128, which are formed separately. The outer cylinder 70 has the construction shown in Figure 11, which is identical to that of the outer cylinder 70 shown in Figure 8.

The sealing partition members 127 and 128 are made of the same material as that of the outer cylinder 70. The first sealing partition member 127 has generally the shape of an annular plate having a centre hole 101, three equiangularly spaced holes 102 distributed thereabout, recesses 103 formed in the circumference of the plate and communicating with the corresponding holes 102 and three pairs of spaced parallel radially extending lugs 104 extending from one surface. The second sealing partition member 128 carries an integral coaxial cylinder 111 integral with which are three elongate equiangularly spaced radially projecting walls 112.

Integral with one end of the cylinder 111 is a bowl-shaped structure 114 comprising an axially extending wall at the free end of which is a substantially radially extending peripheral flange. Three equiangularly spaced holes 115 are formed in the base of the structure 114 and three corresponding recesses 116 communicating with the holes 115 are formed in the axial wall of the structure 114.

This embodiment is used as follows: Three electric cables 3, each connected at one end to a controller, are passed through the through holes 11 of a plug member 10 and then through the outer cylinder 70 and their free ends are then stripped to expose the copper wires 13.

Three electric cables 2, each connected at one end thereof to an electrical device, is passed through the through holes 11 of the plug member 9 and the free ends of the electric cables 2 are stripped off to expose the copper wires 13. The electric cables 2 and 3 are electrically connected by fastening the corresponding copper wires 13 together with the joint terminals 14 by crimping the joint terminals 14.

Each electric cable 3 is fitted in a hole 102 through the associated recess 103 of the first sealing partition member 127, and each electric cable 2 is fitted in a hole 115 through the corresponding recess 116 formed in the dish-shaped structure 114 of the second sealing partition member 128. Then, the first sealing partition member 127 and the second sealing partition member 128 are assembled by firmly inserting each end of the partition walls 112 of the second sealing partition member 128 into the gap between a pair of the lugs 104 so as to dispose each electrical junction formed with one joint terminal 41 in the space between two adjacent partition walls 112.

The assembly of the first sealing partition member 127 and the second sealing partition

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member 128 is inserted into the cavity of the outer cylinder 70 through one open end (the left-hand open end in Figure 10) until the first sealing partition member 127 is brought into abutment with the annular protrusion 71. When the assembly is firmly inserted into the cavity of the outer cylinder 70, the outer circumference of the first sealing partition member 127, the rim of the dish-shaped structure 114 and the edges of the partition walls 112 of the second sealing partition member 128 are in contact with the inside surface 19 of the outer cylinder 70.

The plug member 9 is pushed into the open end (left end in Figure 10) of the outer cylinder 70 so as to abut the end surface of the dish-shaped structure 114 of the second sealing partition member 128 and is elastically held there.

The fluidized filler 6 is poured into the space between the plug member 9 and the dish-shaped structure 114 through the hole 101 in the first sealing partition member 127 and through the centre hole 113 of the short cylinder 111 of the second sealing partition member 128. The filler 6 thus poured into the space is allowed to flow into the spaces around the junctions between the copper wires 13 formed with the joint terminals 14 through the recesses 115 of the structure 114 to fill up the space defined by the short cylinder 111, the inside surface 19 of the outer cylinder 70 and the partition walls 112. When at least the space between the plug member 9 and the first sealing partition member 127 within the outer cylinder 70 is filled with the filler 6, the supply of the filler 6 is interrupted. After the filler 6 filled in the space has solidified, the first sealing partition member 127, the second sealing partition member 128 and the sealing outer cylinder 70 are joined integrally and the junctions between the copper wires 13 formed with the joint terminals 14 are buried within the filler 6.

The use of the sealing member 150 for sealing and connecting electric cables facilitates the work considerably, since the electric cables 2 and 3 are connected with the joint terminals 14 visible, the first sealing partition member 127 and the second sealing partition member 128 are assembled after the electric cables 2 and 3 have been connected and received in the sealing partition members 127 and 128 and then the assembly of the first sealing partition member 127 and the second sealing partition member 128 is inserted into the outer cylinder 70.

It will thus be seen from the above description that, according to the present invention, since two separate electric cables, one of which may be submerged in a hydraulic fluid within a housing and the other extending outside the housing, are used instead of a single continuous electric cable for connecting an electrical device which operates within the housing and a controller which is located outside of the housing and is adapted to control the electrical device and those two electric cables are electrically connected in the interior of a sealing member which is attached in a hole formed in an electric cable lead-out portion of the housing in a liquid-tight manner, the electric cables outside of the housing may be inexpensive electric cables, such as ordinary polyethylene cables, in practical applications, even though electric cables, such as Teflon cables which are superior in oil-resisting and heat-resisting properties and yet expensive, have to be used for the electric cables which are used within the housing. The hydraulic fluid will not be allowed to leak out from the housing into the sealing member and, in particular, will not be allowed to pass to the controller through the electric cable extending outside the housing, since the respective ends of those electric cables are stripped off for electrical connection and the space around the junction of the electric cables is filled with an insulating, oil-resisting and heat-resisting synthetic resin filler so that gaps between the insulation and the copper wires and between the copper wires are filled up with the filler, even if the hydraulic fluid penetrates the electric cable arranged within the housing due to capillarity.

Furthermore, since the electrical device and the controller are generally connected with a plurality of electric cables, a plurality of junctions are formed within the sealing member for connecting the electric cables arranged within the housing and the electric cables arranged outside of the housing, and it is thus necessary to dispose the plurality of junctions within the sealing member in order and to insulate the junctions from each other. According to the present invention, a predetermined number of holes corresponding to the number of the electric cables are formed both in the first partition wall of the sealing partition member and in the plug member around the central axis at equal circumferential intervals and the electric cables arranged outside and inside of the housing are electrically connected after they are passed through those holes. The electrical junctions are disposed in a respective space formed by partitioning the space between the short cylinder of the sealing partition member and the outer cylinder into a predetermined number of spaces with a predetermined number of the second partition walls formed radially on the sealing partition member. Thus the electric cables are prevented from contacting one another and the junctions are separately buried in the filler, and hence the electric cables are effectively insulated and are firmly held by the sealing member.

Furthermore, since the short cylinder is formed substantially in the center of the sealing partition member, the plug member is inserted in the sealing outer cylinder and is held at a small distance from one end of the short cylinder and the filler is poured into the sealing outer cylinder from the other end of the short cylinder through the axial center hole of the short cylinder. The filler first flows into and fills up the space between the short cylinder and the plug member and then flows into the fills up the spaces which are defined by the second partition walls of the

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sealing partition member, the outer circumference of the short cylinder and the inside surface of the sealing outer cylinder and containing the junctions of the electric cables. As the filler is poured into the sealing outer cylinder, the air contained within those spaced is discharged through gaps between the holes formed in the first partition wall and the electric cables and additional air vents. Air will therefore not remain within the filler, hence, pin holes, which cause leakage of the hydraulic fluid, will not be formed in the filler. Still further, since the filler fills up the axial center hole also, the cavity of the sealing member, at least the space between the plug member and the first partition wall is filled with the filler to prevent the leakage of the hydraulic fluid through the cavity of the sealing member.

In connecting the electric cables at the corresponding ends thereof in accordance with the present invention, the joint terminals can be positioned at a position adjacent to the first partition wall by pulling the electric cables which are passed through the holes of the first partition wall, when the electric cables are joined by caulking joint terminals having a shape which will not pass through the holes of the first partition wall of the sealing partition member.

Furthermore, the construction of the sealing member and the sealing outer cylinder and the sealing partition member which are formed separately, allows the visible positioning of the junctions of the electric cables.

Claims

1. A device for connecting and sealing the ends of a first set of n electrical cables to the ends of a second set of n electrical cables in an aperture in a housing, where n is an integer in excess of 1, the device including a hollow, substantially cylindrical, open-ended outer member, an annular flange extending substantially radially from the outer surface of the outer member and a circumferential engagement portion on one side thereof adapted to contact the edge of the aperture in the housing, the outer member accommodating a sealing partition member comprising a hollow cylindrical portion shorter than the outer member and disposed substantially coaxially therewith, a first partition wall at one end of the cylindrical portion having n holes formed therein and extending substantially radially between the outer surface of the cylindrical portion and the inner surface of the outer member and n second partition walls extending substantially radially from the cylindrical portion and extending axially beyond the cylindrical portion at at least one end thereof and two plug members of resilient material each having n holes formed therein and being accommodated within a respective open end of the outer member.

2. A device as claimed in Claim 1 in which the first partition wall has one or more air vent holes formed in it.

3. A device as claimed in Claim 1 or Claim 2 in which the sealing partition member comprising the cylindrical portion and the first and second partition walls is an integral unit which is removable from the outer member and the first and second partition walls contact the inner surface of the outer member.

4. A device as claimed in Claim 3 in which the holes in the first partition wall communicate with the outer periphery of the first partition wall.

5. A device as claimed in Claim 1 comprising three separate components, namely the outer member, a first substantially planar sealing partition member comprising a first partition wall extending substantially radially within the outer member having a central hole formed in it and n holes arranged around the central hole and communicating with the periphery of the first sealing partition member and a second sealing partition member including the hollow cylindrical portion to one end of which a bowl-shaped structure is connected and the peripheral surface of which carries the n second partition walls, the bowl-shaped structure having a substantially radially extending portion with a central hole formed in it and n holes arranged around the central hole and communicating with the periphery of the radially extending portion and a substantially axially extending portion in which apertures are formed in positions corresponding to and communicating with the n holes in the radial portion, the peripheral region of the first sealing partition member carrying n pairs of spaced projections between which the n second partition walls are retained, the inner surface of the outer member carrying an annular protrusion engaged by the first sealing partition member.

6. A device as claimed in any one of the preceding claims in situ in an aperture in a housing connecting the ends of two sets of n electrical cables, the first set of cables passing through respective holes in one plug member and the second set of cables passing through respective holes in the other plug member and in the first partition wall, their ends being connected to those of the first set of cables of connectors which are accommodated in respective peripherally spaced spaces defined by adjacent pairs of second partition walls, at least the space between the first partition wall and the plug remore therefrom being filled with an electrically insulating synthetic resin material.

7. A device as claimed in Claim 5 and Claim 6 in which the second set of cables pass also through respective holes in the radially extending portion of the bowl.

8. A device as claimed in Claim 6 or Claim 7 in which the connectors comprise crimped metallic plates and are of a size which will not permit them to pass through the holes in the first partition member.

9. A device as claimed in Claim 6 or Claim 7 or Claim 8 in which the housing is the housing of a hydraulic machine and the two sets of cables are connected respectively to an electrical device

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within the housing and to an electrical controller outside the housing.

10. A device for connecting and sealing the ends of a first set of n electrical cables to the ends of a second set of n electrical cables in an aperture in a housing substantially as specifically herein described with reference to Figures 1 to 7, Figures 8 and 9 or Figures 10 to 12 of the accompanying drawings.

11. A method of connecting and sealing the ends of a first set of n electrical cables to the ends of a second set of n electrical cables in an aperture in a housing using a device as claimed in any one of Claims 1 to 5 and 10 in which the ends of the first set of cables are passed through respective holes in one plug member, the ends of the second set of cables are passed through respective holes in the other plug member and in the first partition wall, the two sets of cable ends are connected, the connections situated in respective peripherally spaced spaces defined by adjacent pairs of second partition walls, the one plug member is inserted into one end of the outer member to define a gap between it and the adjacent end of the hollow cylindrical portion, an electrically insulating flowable synthetic resin material is introduced through the hollow cylindrical portion to fill at least the space between the one plug member and the first partition wall, the other plug member is inserted in the other end of the outer member and the device is inserted into the aperture in the housing with its circumferential engagement portion engaging the edge of the aperture in a liquid-tight manner.

12. A method as claimed in Claim 11 which includes inserting the sealing partition member into the outer member after the end of the second set of cables have been passed through the holes in the first partition wall.

13. A method as claimed in Claim 11 or 12 using a device as claimed in Claim 5 in which the second set of cables are passed through the holes in the first partition wall by moving them radially through the spaces by which the holes communicate with the periphery of the first partition member and through the holes in the radially extending portion of the bowl-shaped structure by moving them radially through the apertures in the axially extending portion of the bowl-shaped structure and through the spaces which the holes communicate with the periphery of the radially extending portion and the first and second sealing partition members are connected and inserted into the outer member prior to the insertion of the one plug member.

14. A method of connecting and sealing the ends of a first set of n electrical cables to the ends of a second set of n electrical cables in an aperture in a housing substantially as specifically herein described with reference to Figures 1 to 7, Figures 8 and 9 or Figures 10 to 12 of the accompanying drawings.

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